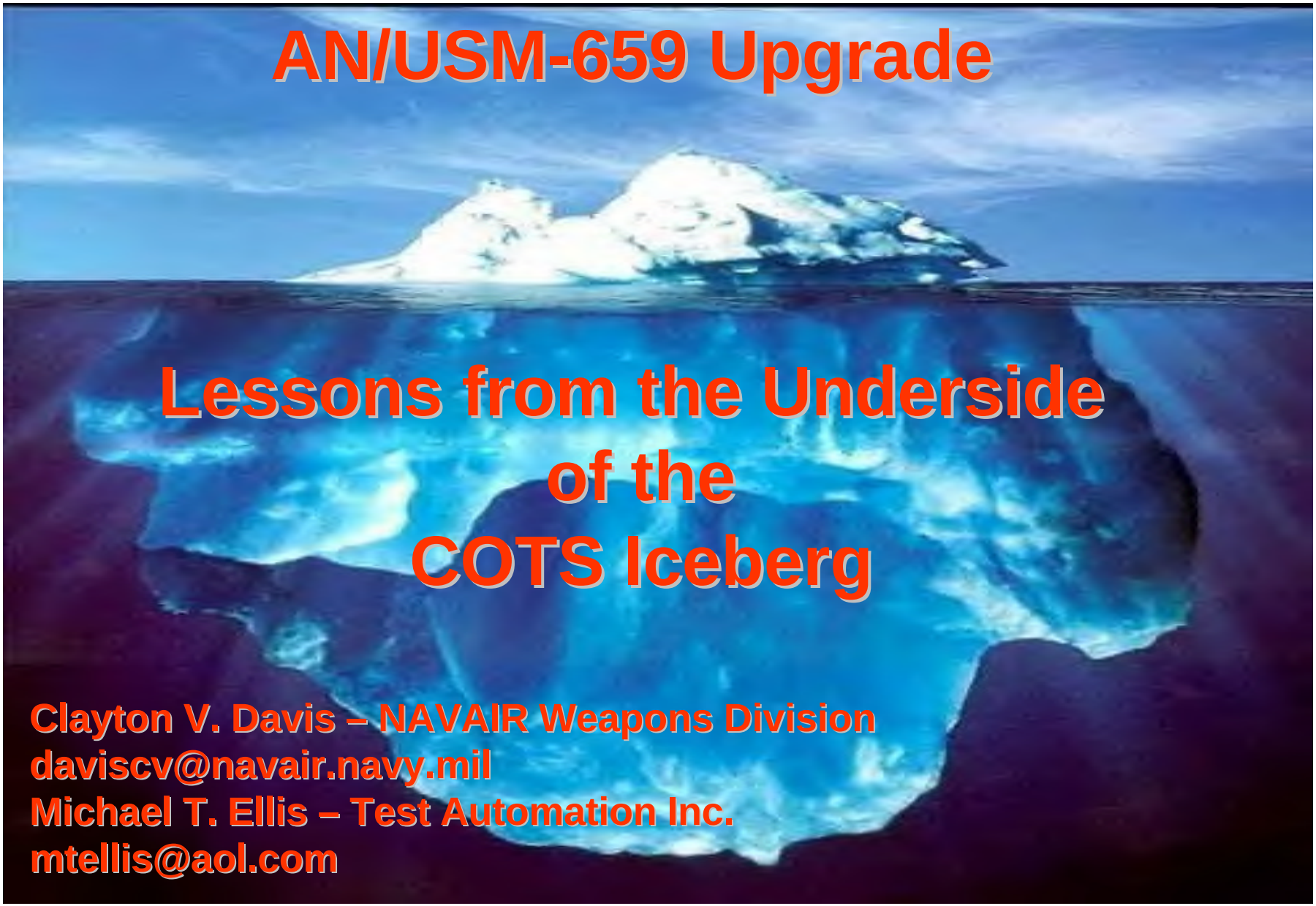
AN/USM-659 Upgrade



Lessons from the Underside of the COTS Iceberg

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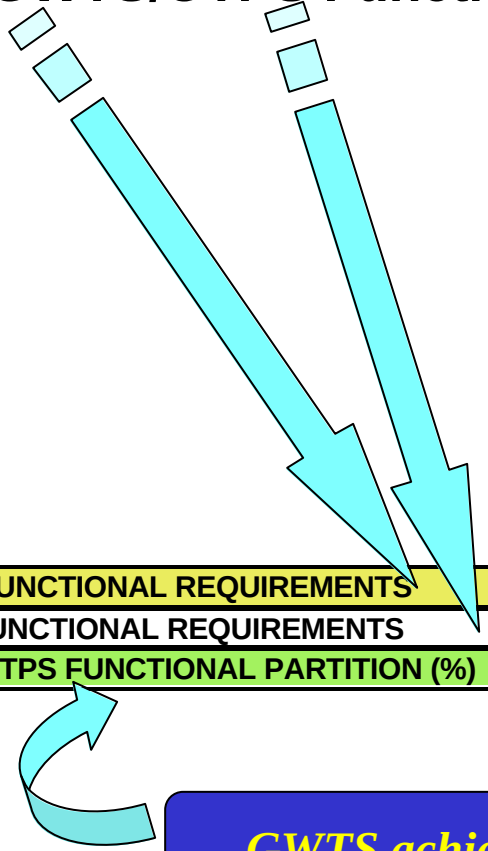
Overview

- The AN/USM-659 Guided Weapons Test Station is a complex Intermediate/Depot Level Automatic Test Set designed to performance test and fault isolate eighteen tactical guided weapons
- The system is “98% COTS”
- The system passed acceptance test in 1999. Seven systems were delivered. The system is currently testing AMRAAM and ESSM
- In 2000 an upgrade system was ordered by Taiwan
- The lessons learned in this upgrade are applicable to any complex COTS systems

DESIGN RESULTS

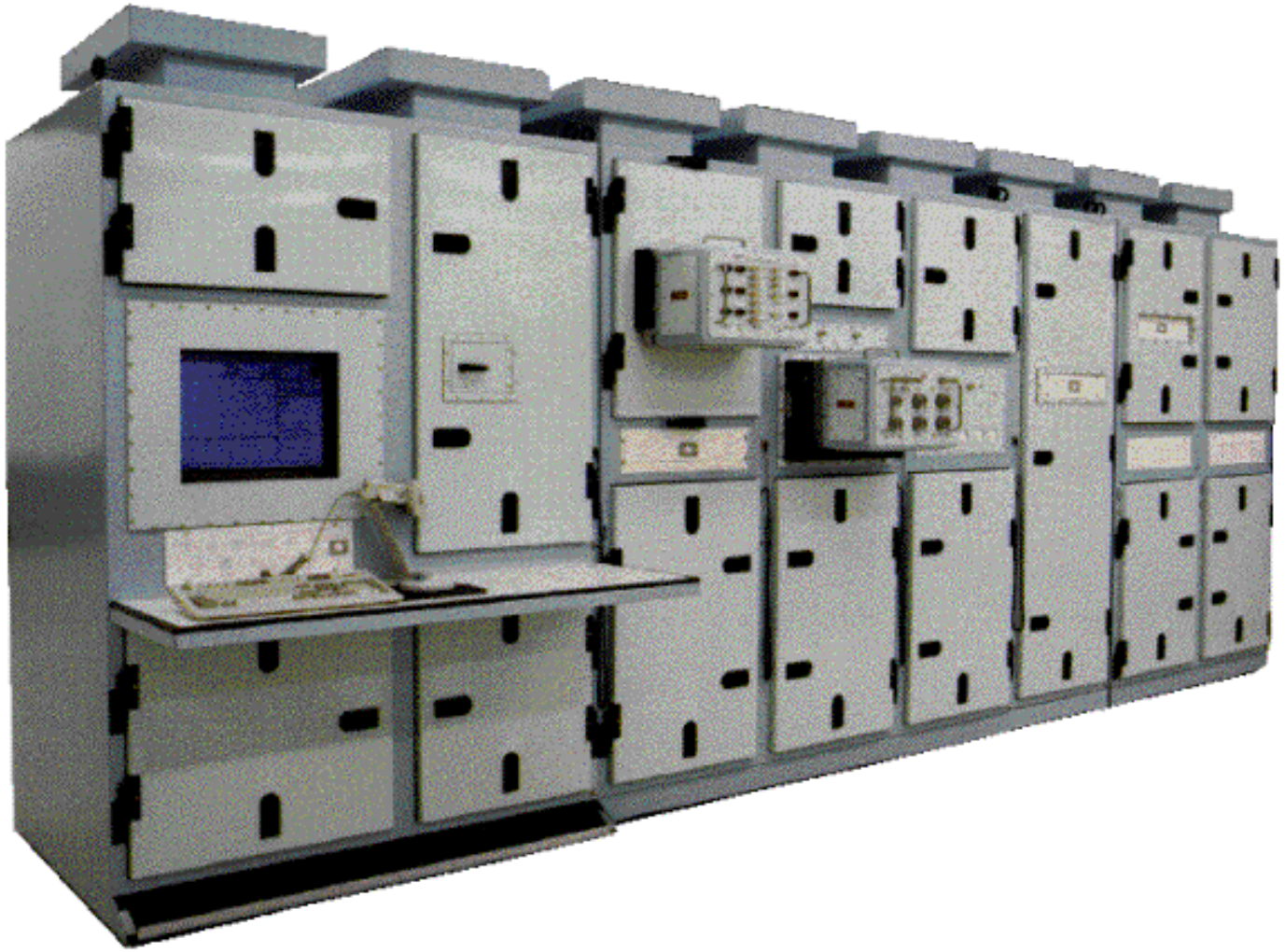
GWTS/OTPS Functional Partitioning



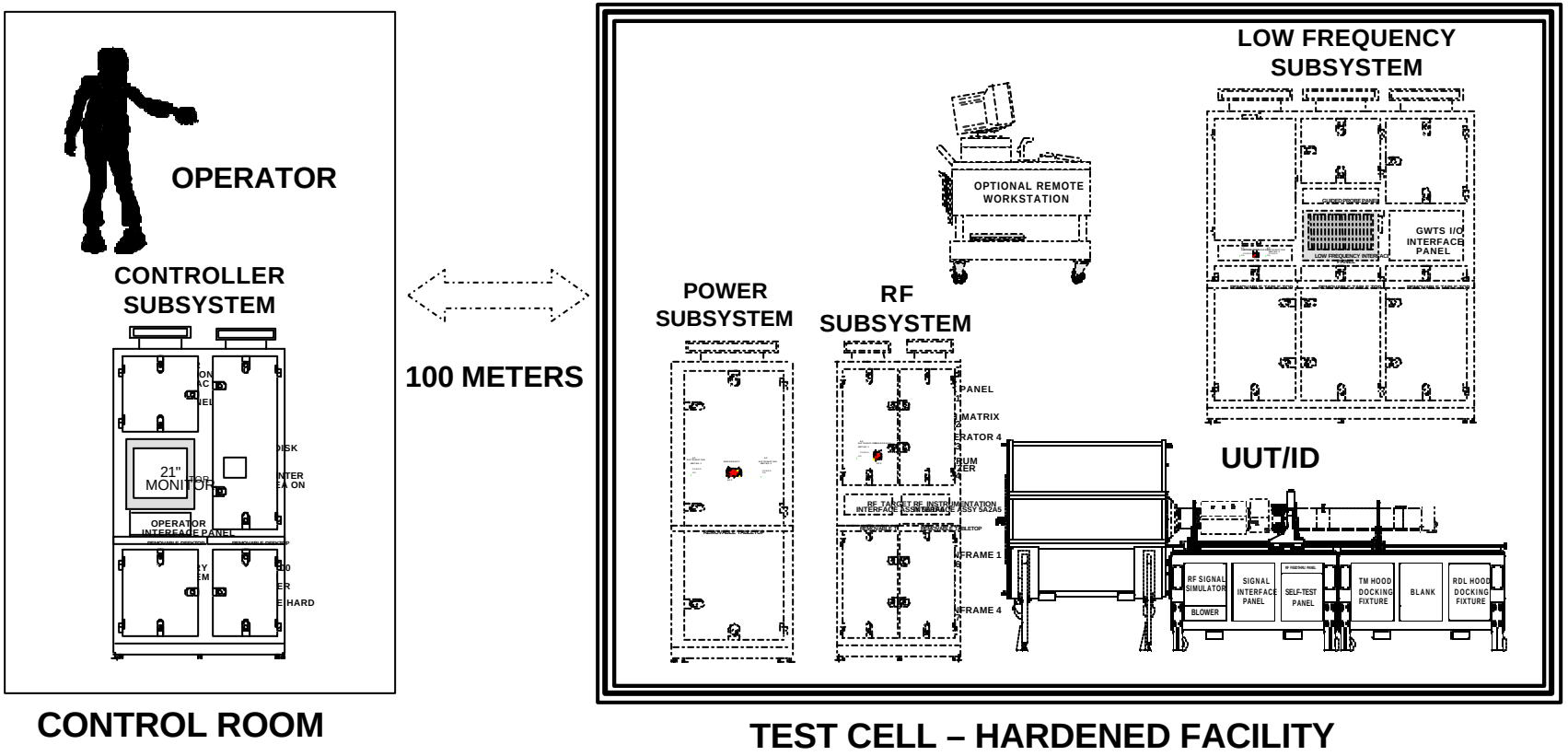
	RF MISSILES									EO MISSILES					TORPEDOES			
	AMRAAM	PHOENIX	SPARROW	STANDARD MR	STANDARD ER	HARM	HARPOON	SLAM	TOMAHAWK	SIDEWINDER	MAVERICK	CHAPARRAL	STINGER	RAM	MK46	MK48	MK48 ADCAP	MK50
GWTS FUNCTIONAL REQUIREMENTS	88	89	84	70	70	69	73	67	68	64	66	64	57	65	48	60	61	48
OTPS FUNCTIONAL REQUIREMENTS	22	21	22	22	22	16	20	23	22	21	22	21	20	22	16	19	19	15
GWTS/OTPS FUNCTIONAL PARTITION (%)	80	81	79	76	76	81	78	74	76	75	75	75	74	75	75	76	76	76

GWTS achieves greater than 70% of **munitions** *test functions*

The System



The System in Use (1)



The System in Use (2)

TEST CELL

CONTROL ROOM

System Component Selection

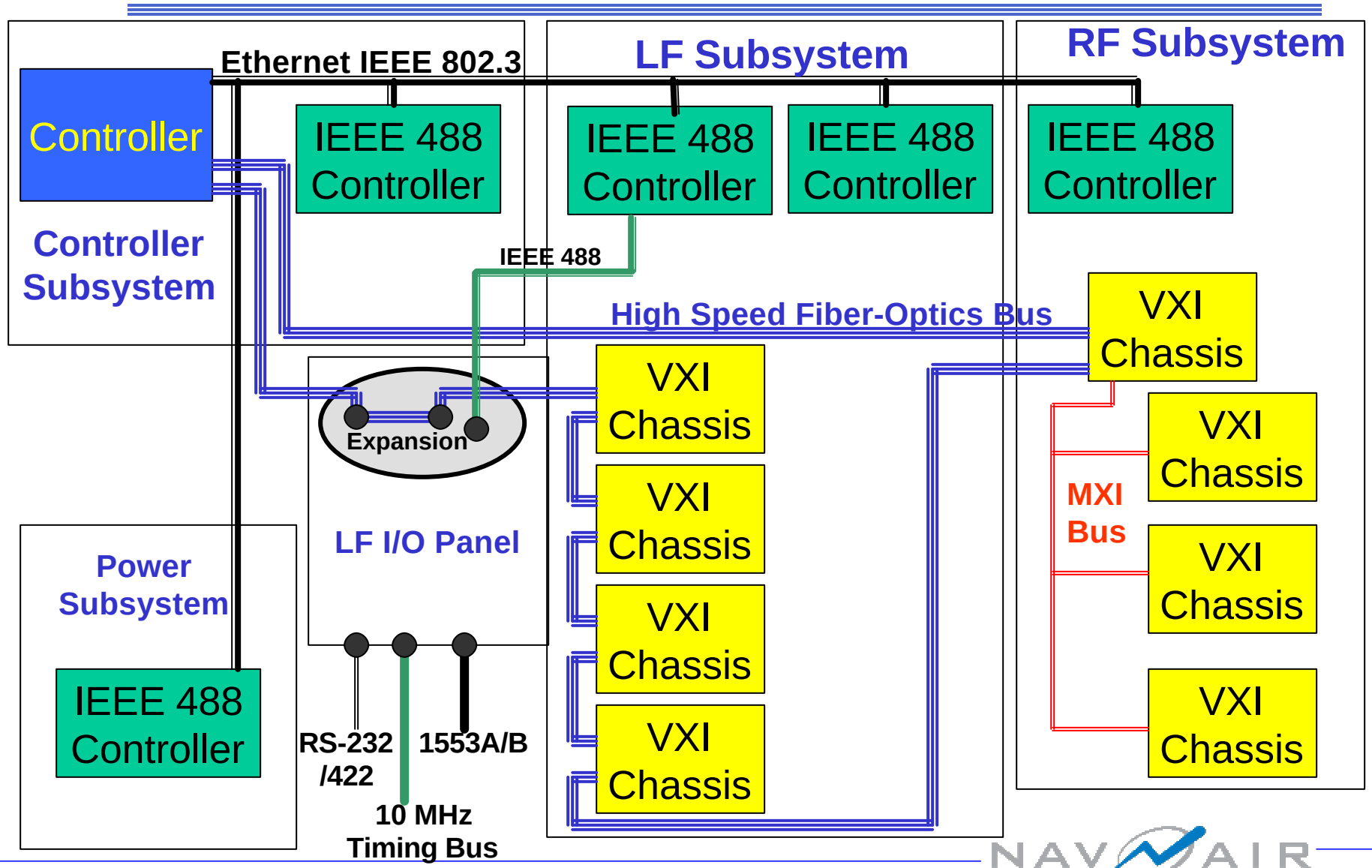
- The system design made maximum use of industry standards
- The system used COTS hardware and software

Top-Level System Description

- The GWTS uses a DEC Alpha computer, running under UNIX to control approximately 100 devices/instruments
- Instrument control is programmed via Ada
- All instruments are IEEE 488 or VXI
- Four standard busses, IEEE 802.3 (Ethernet), IEEE 488 (GPIB), VXI and MXI are used for instrument control
- One COTS non-standard fiber-optics bus is used to provide ultra-fast control of some instruments
- Three well-established COTS Software packages were employed for Ada programming and editing, screen design and data base design and application

Items in red are industry standards

GWTS Instrument Bus Structure



GWTS Obsolescence

- By acceptance, in 1999:
- DEC Alpha COTS computer and several peripherals were obsolete
- Two critical general-purpose COTS instruments were out of production
  - DMM
  - DTU
- Several special purpose COTS components were unsupportable based on:
  - Manufacturer being bought-out
  - Product line being dropped

Taiwan Upgrade

- GWTS obsolescence management is via “rolling upgrades” or “technology refreshment”
- Upgrade compatibility was to be traceable through the Prime Item Development Specification
- Taiwan Upgrade had four major elements:
  - Upgrade computer and operating system to the *de facto* standard– PC/Windows
  - Rehost existing software (400k l.o.c)
  - Upgrade DMM
  - Upgrade DTU
- Ada programming language was to be retained
- COTS software packages were to be retained if possible

Risk Assessment

- In a public-forum paper (AUTOTESTCON) written in mid 2000, the GWTS Chief Engineer, Steve “Cassandra” Stanfield identified the highest risk component as the non-standard, COTS high speed bus
- Note that at that time, no other bus could provide the required 80 MHz data rate over the 100 meter distance
- Second highest risk was the portability of the COTS software to the new operating system environment

Travel with us now to the days of yester(last) year. Witness heroic feats of systems engineering. Watch as team members defy cost and schedule constraints. Share the thrill of small victories and the agonies of temporary defeats.

The Adventure Begins……..

Step 1 – Pick Your OS Software – The Theory

- The first, and most significant step was to pick the new operating system
- A study conducted by NAVAIR WD and Raytheon in Jan/Feb 2000 reviewed the following operating systems:
  - Windows 98
  - Windows NT
  - Windows 2000
  - LINUX
  - LINUX/RT
  - Solaris 8
  - HP-UX
  - MAC-OS
  - LYNX
  - VxWorks
  - QNX
- Study recommended Windows 2000, Microsoft's "OS for the next millennium", certainly the best solution
- We thought…

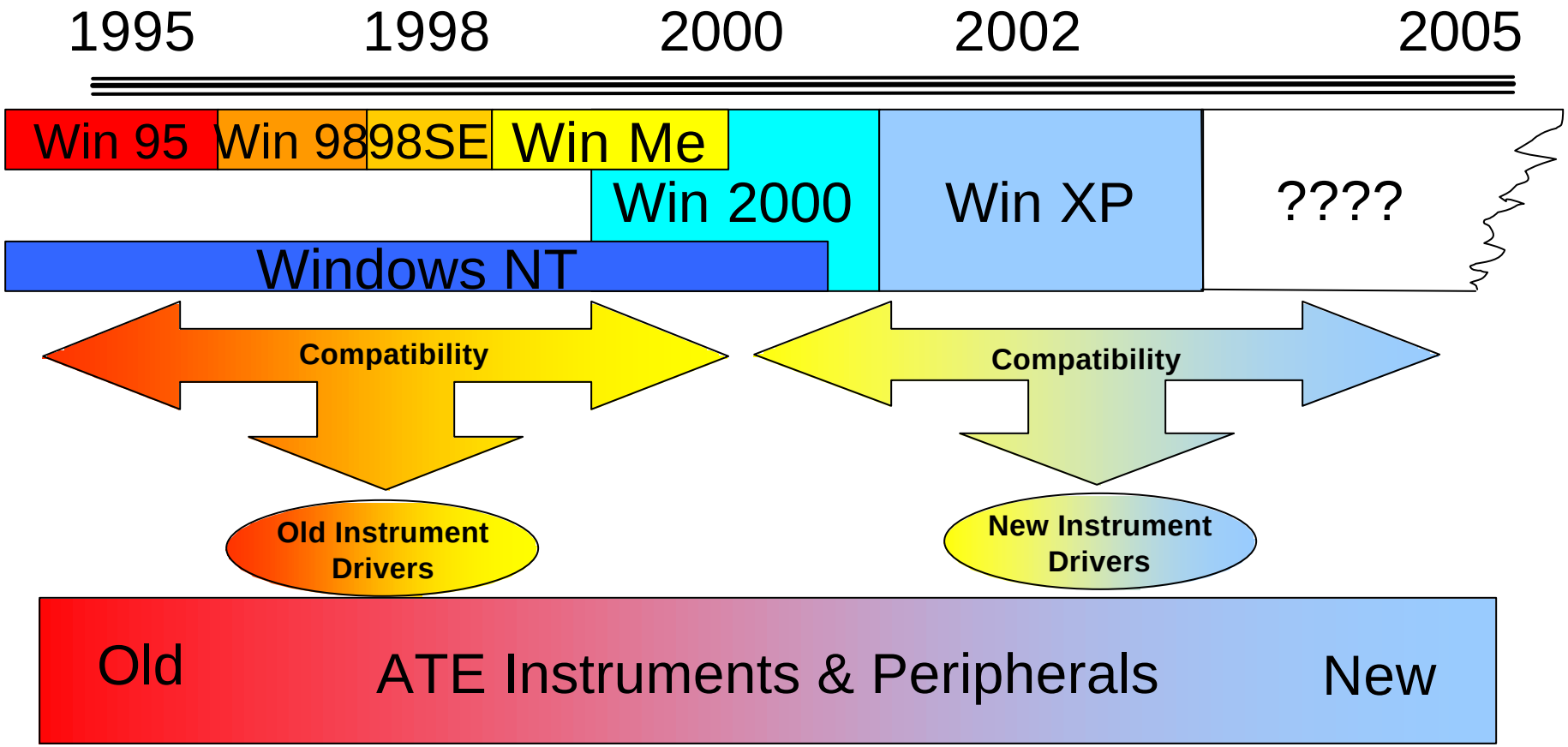
Step 1a – Pick Your OS Software – The Reality

- One month later…..
- Microsoft's "real" OS for the millennium will be XP
- Windows 2000 will not be supported past 2004 (Microsoft guidelines – product enters "Non-supported phase after four years of general availability")
- Reset! Tilt! Now what? @#$%^^!!!!

So Where Are We?

- Windows is the *De Facto* Operating System Standard
- Upward compatibility (drivers, etc.) and support vary
- Look at the recent history of the “standard”
  - Windows 95 - Lifetime 2-3 years
  - Windows 98/98 SE - Lifetime 1-2 years
  - Windows Me - Lifetime 1 year
  - Windows 2000 - Lifetime 1 year
  - Windows XP - ?????
- In six years we have seen five standards!

PC Operating System Obsolescence



Current

Obsolete

The COTS Software Challenge

- A military system has a lifetime of 20-30 years
- The use of COTS makes the system more flexible, and lowers development costs
- An instrument/peripheral lifetime is 2-5 years
- During the system life, its components will become obsolete between 5 and 15 times!
- When new components are required, they will probably not have drivers for old operating systems
- If the operating system is upgraded, there will probably be no drivers for old components

Step 1a - The OS Decision

- The DIYD²* decision, select Windows NT
- Rationale
  - Largest installed commercial base
  - Drivers available for all legacy and upgrade instruments
  - Stable platform

* Damned-If-You-Do, Damned-If-You-Don't

Lesson 1

- What your Grandmother told you:

  "You can't teach an old dog new tricks"

- What COTS told you:

  "It might be easier to teach an old dog new tricks than teach a new dog old tricks"

Step 2 – Supporting Software

- The three COTS software support packages provided:
  - Ada Compiler, Coding and Editing
  - Screen Building and Editing
  - Data Base Design and Application
- Ada Compiler package *is* NT Compatible
- Screen Builder *is not* NT compatible
- Data Base *is not* NT compatible

Step 2 - Decisions

- Replace screen builder with new screens designed in C++
- Replace data base with MS Access
- Note: Part of our “software rehost” has now become “software redesign”
- C’est la vie!

Lesson 2

- What your (French) Grandmother told you:
  - “Plus ça change – plus la même chose”
  - [The more things change – the more they are the same]
- What COTS told you:
  - “Plus ça change – plus la difference”
  - [The more things change – the more they are different]

Step 3 – Change the Computer

- Environment - April 2000 – Pentium III is the processor-of-the-day; Pentium 4 is new and unproven
- Good news – smart move….(at last)
- We can develop on any PC platform so we'll delay the computer selection until later
- Final Decision – January 2002 – selected dual-processor Pentium III's
  - Dual processor better fits our application
  - P4 has some problems in dual processor mode with our application and configuration

Lesson 3

- What your Grandmother told you:
  - “Don’t put off ‘till tomorrow what you can do today”
  - “The early bird gets the worm”
- What COTS told you
  - “Don’t rush into decisions today that can be made tomorrow”
  - “The early worm gets the bird!”

Moving Right Along….

- All acquisition decisions were now made
- New hardware seemed to pose no significant problems
- Some software rehost had become software redesign
- One hiccup – the fiber-optics bus driver, advertised as available for NT in August 1999 did not become available until August 2000 [What did that AUTOTESTCON paper written in mid 2000 say again..]
- Let's move to the beginning of the integration phase – August 2000

Step 4 - Integration

- Outside of the software development issues, the primary task in integration is to make sure we can talk to and control the 100 or so instruments
- These instruments are of three types
  - IEEE 488
  - VXI Register Based
  - VXI Message Based
- We have (cleverly) assigned two GWTS systems to maximize efficiency during integration

Dawn Breaks on the Integration Phase..

- First the good news..
  - The system powers up under the new software
  - The register based VXI instruments are all present and correct
- Now the bad news
  - Some of the GPIB controllers don't work
  - None of the VXI message based instruments want to talk to us
- So dawn wasn't the only thing broken..

First Things First…the GPIB Controllers

- After months of extensive investigations, with little help from the manufacturer, we find out that the PROM software in some of the controllers is different even though it has the same revision number
- We update the PROM software and BINGO – IEEE 488 is “in business”

Lesson 4

- What your Grandmother told you:

  "The old brown cow she ain't what she used to be"

- What COTS told you:

  "The new CM (Configuration Management) she ain't what she used to be"

And Now for the Fiber Optics Driver..

- The fiber optics bus driver initial release was almost a year late
- The slip took place month-by-month..”Don’t worry, we’re shipping it next month…”
- And there was more..

Fiber Optics Driver – Summary Chronology

- Initial delivery in August 2000 did not include message-based drivers
- October 2000 update still not functional with message-based instruments
- Aug. 2, 2001 – NAVAIR-WD identifies new update delivered library as incomplete – cannot compile driver set
- Nov. 17, 2001 – Company X releases needed library components
- Dec. 2001 - Driver compiles but fails to operate with message-based instruments and all MXI instruments
- Jan. 15, 2002 - Company X requests typical message-based instrument and duplicates problem
- Mar. 22, 2002 – New release.
- April 2002 – New release works with all non-MXI instruments individually, but fails with instrument combinations
- May 8, 2002 – NAVAIR-WD identifies specific problem combinations
- May 20, 2002 – Company X requests second instrument
- May 23, 2002 – Company X duplicates problem
- May 29, 2002 – “Fix” released – only fixes the two instrument combination at Company X
- July, 2002 – Message based instrument fix works. MXI still a problem
- September 2002 – MXI issue fixed (Driver now at Rev 7), still minor problems with some protocols

Cassandra's Prophecy - Lesson 5

- What your Grandmother told you:
  - "Every black cloud has a silver lining"
  - "Tomorrow is another day"
- What COTS told you:
  - "Some silver linings have a black cloud"
  - "Tomorrow is another month (or year)!"
- What they agreed on:
  - "If at first you don't succeed, try, try again."

And the Judge Says…..

- Don't plan on advertised delivery dates
- Avoid single source products where possible (we couldn't)
- You were unlucky – this problem may not be typical
- …or perhaps it is!
  - Many DoD systems are more complex than their commercial counterparts – ours was!
- The bad news – the vendor had (has?) major problems with the "COTS" product
- The good news – this vendor provided tens-of-thousands of dollars of support (AND SO DID WE!) for a $3k product over a period of three years! That certainly is *not* typical!
- Resolution of unique problems may only be possible with vendor cooperation and "same system" simulation
- Don't alienate the vendor – they're your only source of information and support

Observations

- With COTS software you are at the mercy of the vendor if problems arise
  - You have no source code
  - You have no control of the COTS testing and certification process
  - You can't control or make product changes
  - You can't control the update delivery schedule
- Wherever possible, "Fly before buy"
- Avoid unique products if possible
- Documentation is probably inadequate at best
- Don't alienate the vendor – they're your only source of information and support

On the Subject of Vendors..

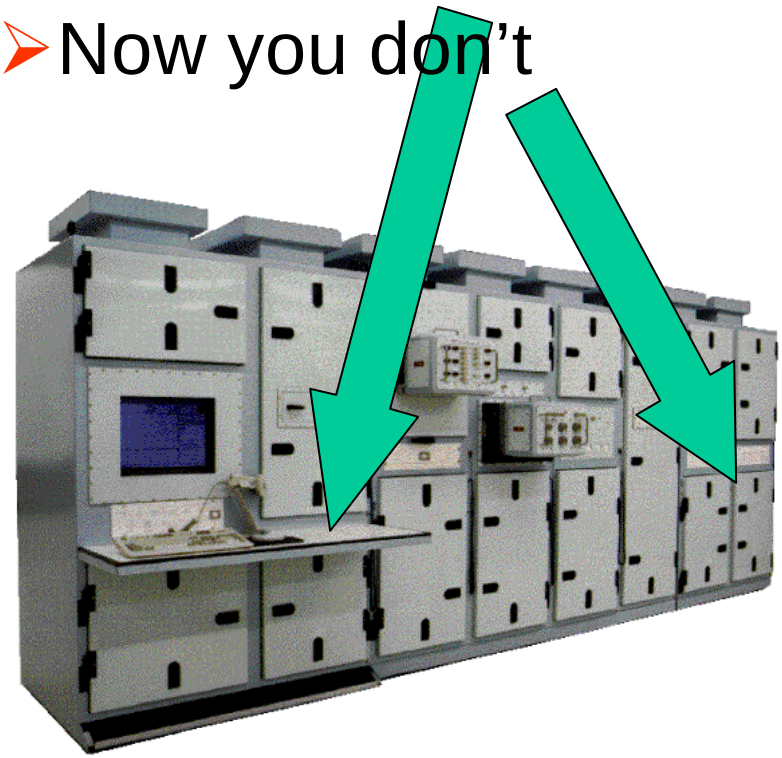
- In today's market, vendors can become history quickly
- Example from AN/USM-659 development
  - Several critical instruments were bought from Watkins Johnson; a well-established, highly respected company…but
  - WJ was bought by Stellix…and
  - Stellix was bought by M/A Com
- Product support and product expertise may not survive acquisition
- Vendors, also go out of business, or go out of *"that"* business

Lesson 6

- What your Grandmother told you:
  - "Nothing lasts forever"
  - "Here today, gone tomorrow"
- What COTS told you:
  - "Nothing lasts forever, including support, reacquisition and spares"
  - "Here today, gone tomorrow. Today's supportive vendor may be tomorrow's long-lost friend"

Step 5 – Delivery: From the Horrific to the Hilarious..

- Moving from profound to pedantic we will now discuss….shelves!
- Now you see ‘em!
- Now you don’t



- ✓The GWTS was designed to allow shelves on all bays
- ✓In the lab, only the controller subsystem racks (1 and 2)were fitted with shelves
- ✓And thereby hangs a tale…

What Happened Next…

- When the system was delivered to Taiwan in August 2002, the shelves for the RF Subsystem, Racks 7 and 8 did not fit!
- Come to find out…
  - The COTS racks delivered with the seven GWTS systems had three different shelf mounting systems, all with the same rack part number
  - We never used the shelves in the lab
  - We shipped the shelves for the lab system with the delivered system!

Lesson 7

- See Lesson 2 – Configuration Management
- Most COTS vendors reserve the right to change their product without notification
- These changes may or may nor result in a different part number
- What your (Roman) grandmother told you:

  "Caveat Emptor – Buyer Beware"

Step 6 – Lick Your Wounds and Reminisce

- Enough of our “bad luck”, stupidity, challenges, did we learn anything?

Lesson 8

- What your grandmother told you”

  “Learn from other people’s mistakes”

- What COTS told you

  Sometimes you’re the “other people”

  “Plagiarize, plagiarize; let no one else’s work evade your eyes” Tom Lehrer

On the Subject of Plagiarism….

Extracts from "The Commandments of COTS" - Carney & Oberndorf, Software Engineering Institute, Carnegie Mellon University. Published in Crosstalk, May 1997

- **Do Not Believe in "Silver Bullets"**
- **Use the Term Precisely and Demand the Same from Others.**
- **Understand the Impact of COTS Products on :**
  - **Requirements & Selection**
  - **Integration**
  - **Testing**
- **Realize that a COTS Approach makes a System Dependent on the COTS Vendors**
- **Realize that Maintenance is Not Free**
- **You are Not Absolved of the Need to Engineer the System Well**
- **Just "Doing COTS" is not an Automatic Cost Saver**
- **"Doing COTS" must be part of a Large-Scale Paradigm Shift**

AMEN!!!

What Did We Learn…Software

- Software is a major problem:
  - Old instruments/devices may not have drivers for new Operating Systems
  - New Instruments may not have drivers for old Operating Systems
  - You will almost never get source code for COTS software..so..
  - You are at the mercy of the vendor
  - Configuration Management practices, or lack thereof, are determined by the vendor

What Did We Learn…Hardware

- You are at the mercy of the vendors
- Configuration Management practices, or lack thereof, are determined by the vendors
- Vendors come, and vendors go… and with them spares and support
- A system of COTS is not a COTS system
- Just because its “off-the-shelf” doesn’t necessarily mean it was ever “on-the shelf”. To be “COTS” requires only a catalog part number and price, not a sustained and supported product line

What Did We Learn… Environment

- Change is constant
- Product lives are 2 – 4 years
- DoD is no longer a big customer
- Good management and good engineering are still critically important….
- So are good suppliers
- Life cycle support planning must include a viable obsolescence upgrade, or technology refreshment plan…
- And budget projection

Rules to Live By

- There is no substitute for good system engineering practices
- Problems come from incompatible lifecycles – recognize this and keep it uppermost in your planning
- In a system of COTS, be sure to follow requirements specification, development specification and product specification practices
- Plan for obsolescence based on realistic lifecycles
- Adopt durable technology standards
- Select reliable, supportive vendors
- Be aware that the point of maximum vendor control is at selection
- Understand that COTS can be a great cost and schedule saver if properly applied… and that
- Proper application is *your* responsibility
- Recognize that COTS is here to stay!

Summary

- The AN/USM-659 upgrade provided many useful examples of COTS risk areas
- In general vendor support was excellent, but m-u-c-h slower than desired
- The problems were not unforeseeable, but the existence of most was beyond developer control
- Even with the problems, the use of COTS hardware and software undoubtedly saved both time and money; but…
- Perhaps not as much as we hoped – so keep expectations realistic,remember…
- Murphy is alive and well and living in COTSville!
- COTS is still a relatively young technology in military applications. We have offered some of our lessons-learned; don't be shy about sharing yours!